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MINI BOILER – CONSTRUCTION DETAILS AND ANALYSIS

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***Abstract*— Various types of boilers are being used today, but they all are bulky and heavy in nature. Through this paper, it has been tried to manufacture and analyze a fire tube boiler that would be transportable in nature. The boiler would have all the necessary safety instruments fixed on it so that the operation of the boiler would be safe for the operator. The main aim behind the construction of this boiler is to make possible the study of the steam properties of the steam generated from this boiler at some future stage.**

***Index Terms*—portable boiler, detachable boiler, transportable boiler, boiler analysis**

I. INTRODUCTION

Boilers are mechanical machines used to transfer heat and mass from one location to another. Almost all industries have a boiler unit in their plants. Boilers may be broadly classified into a water tube and fire tube. In water tube boilers the water is sent through tubes around which a fire is provided, the water in the tubes absorb heat energy from the fire, gets phase changed. The water vapour thus formed is then supplied to various locations in the plant. In the case of fire tube boilers, the fire is sent through the tubes around which the water to be heated is provided. Now a days there are many different types of designs that are coming into the placing of the tubes in the drum, so as to improve the efficiency of the system.

Marine boilers were one of the first implementations where the boilers were made portable in nature. Making the boiler portable in nature also demands the design to be made in such a manner that the boiler is lightweight at the same time not compromising the power that could be produced from it.

Our aim through this project was to design and manufacture a mini boiler having detachable components with no component weighing more than 50 Kgs, to make its transportation easy. In the course of design and manufacturing the standards and norms kept forward by the Indian Boiler Rule 1950 was followed to ensure safety. All the structural components except the inner tubes were used from scrap metals to reduce the cost of the assembly. The boiler was fired using wood waste from a plywood factory.

II. PROJECT OBJECTIVES

The main objective of the project was to develop a mini boiler which would be comparatively small in size as well as can be dismantled and moved effortlessly wherever necessary. This project focuses mainly on the applications where comparatively low pressure steam is required. This project also focuses on situations where temporary steam generation is required where the setting up of a permanent boiler is not feasible.
Some applications aimed with this boiler are in the field of catering, and a medical application where mounting a boiler of large capacity is not feasible as well as its non-economical. In the medical field, it can be used for sterilizing medical equipment in a hospital or clinic or in medical situations during war or a post disaster scenario. This kind of boilers can be used for preparing food items which require steaming during their preparation.

The project objectives can be listed as follows:-

1. To construct a boiler that can be assembled / disassembled without much strain.
2. No individual part of the boiler should weigh more than 50kg.
3. All the parts should be fabricated inside the campus.
4. The design should agree with the specifications laid by IBR 1950.
5. C – class pipe to be used for the fire tubes.
6. To construct the boiler such that the fire tubes in one drum do not align with the tubes in the next drum, this is expected to give a swirling effect to the flue gases and this swirl would increase the heat transferred to the water in the drum.
7. The machine should be fitted with all the necessary safety and subsidiary equipment.
8. The machine should be insulated properly in order to decrease the time taken for the water to get converted to steam.

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9. The machine should be made transportable and the components should be easy to assemble, a worker should be able to see the assembly drawing and should be able to assemble the machine
10. The design should be replicated using a CAD software and should be analysed for failure using a FEA software.
11. If the FEA examination fails then necessary modification should be made to the design to ensure that the design remains safe while in operation
12. The material procurement process should be done in such a manner that the required materials are obtained for the least possible cost at the same time not compromising the safety of the machine
13. The boiler should be fired after the completion of the manufacturing and should be fired only after it has been ensured that there are no leaks present in the water circuits inside the tubes or drums or at the flanges.

In short, the boiler should be made in such a manner that it is lightweight, portable, easy to operate, safe and economical.

III. METHODOLOGY ADOPTED

1. Based on the problem definition we did our background study from various institutes which used boiler for their day to day activities. One was a plywood factory near Pathamuttom and the other one was Hindustan Newsprint Limited, Kottayam. After talking with the operators and engineers, there we decided upon a rough handmade sketch. We searched for the design procedure for pressure vessels and reached at the design values for the drum diameter that was to be used. We referred the IBR 1950 specifications to validate our designs.

2. We procured the required materials for the construction from various scrap dealers.

3. As procured materials were having dimensions greater than the design values, we tested the design using the FEA tool box incorporated in Solid works to find the factor of safety for the drum.

4. Construction of the boiler was completed in the college workshops and labs taking the help from various Lab in charges, Lab Assistants, Machinists, Trade instructors and teaching staff of the college.

5. Water leakage test was conducted after the welding of each drum and the required corrections were made.

6. Final assembly of the machine and water flow checks was conducted on the machine.

7. Based on the adjustments made during construction a final Cad model was made and was analysed using the FEA software

8. After the result of the final CAD analysis firing of the boiler was done using wood waste as fuel.

9. The steam pressure was made to rise till the safety valve was blown.

10. The adjustment on the spring force of the safety valve was done to make the steam pressure set at 5 bar.

IV. MAIN WORK

The hand drawing of the expected boiler was made as shown in the following figure, the drawing contained all the expected features of the final machine. Although later during the analysis and manufacturing stages there were certain changes made to this drawing of the final design was very similar to this figure.

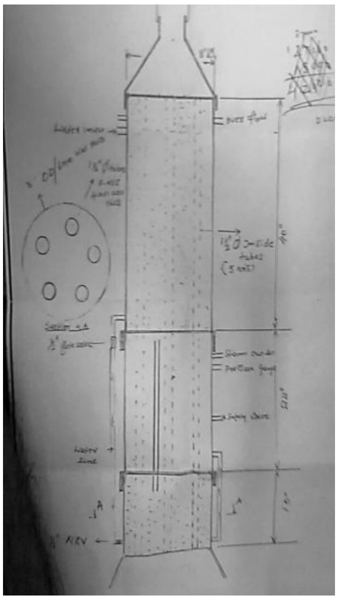

Fig 1.The first hand drawing of the expected boiler

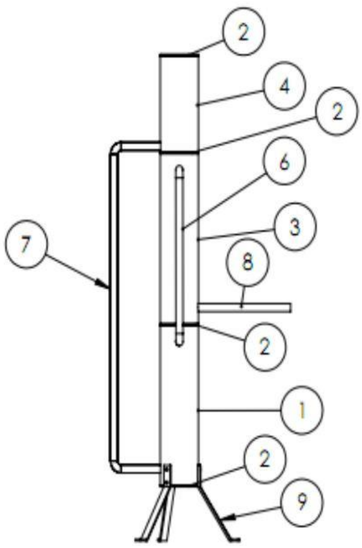

Fig2. Figure of the first CAD drawing, (1) Water drum, (2) Flanges, (3) Superheating drum, (4) Preheating drum, (5) Safety Valve (not shown in this view), (6) (7) Water circuit lines, (8) Steam outlet pipe, (9) Legs

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In the first CAD model, the water from the preheater comes from the bottom most drum enters the middle drum at a level higher than the output valve is placed. This is wrong as the middle drum would be containing condensed water in its lower portion. Changes were made in the subsequent drawings. Also there was no mention of the position of the drums and the inside pipes were not shown.

The hand calculations were made to find the design value for the thickness of the drum. During the hand calculation, the factor of safety was found to be much higher than unity. However, in the hope that future development would require the increase in the pressure of steam generated, we decided to build the boiler with the materials that we had already purchased.

The CAD model was updated based on every change taking place on the shop floor.After the completion of the construction of the boiler the CAD model was given a final structural analysis using the Solid works Toolbox and the final FOS for various components were found out.

The firing was done after making sure that the water lines were leak proof and that the welding did in between the flanges and the drums and between the flanges and the inner tubes were perfect.

The safety valve was calibrated to blow off at the required pressure of steam. The machine was fired using wood waste from a plywood factory.

Fig 3. Steam production from the boiler

V. LIST AND DETAILS OF PARTS

A. Drum:-

The boiler drum consists of 3 major parts each having the same internal diameter of 8 inches and external diameter of 8.75 inches. The differences in the geometry of the drum were in their lengths only. The three drums are

1. Water drum
2. Steam drum
3. Pre heater drum

1. Water drum:-

It is the lowermost part of the drum of the boiler. The part is made of MS pipe having external diameter of 8.75in and internal diameter of 8in. the length of the drum is 15in. both sides of the drum are covered with flanges. One flange comes in contact with the open flame and the other flange contains the seating arrangement for the middle drum.

The drum has the provision for the attachment of the water level indicator, the water inlet from the pre heater and the water outlet to the middle super heating drum. This drum is in contact with the flame and hence it is here that the water is initially converted into steam.

2. Steam drum / super heating drum:-

It is the middle portion of the boiler drum. The part is also made with MS and has the same diameter dimensions as the former part. The length of this part is 22in. in this part the flanges are welded in the inside of the drum at a distance of about 2.5in from the face of the drum. This is to ensure the turbidity of the flue gases that come from the lower drum before entering into the middle drum’s tubes.

This drum has the provision for the attachment of the pressure gauge, the safety valve the inlet from the lower drum and the output pipe that releases steam into the required pipe.

3. Pre heater:-

It is made of the same material as that of the other drums and is also having the same dimensions as the other two drums. This part has a length of 20in. this drum also contains the flanges displaced inside its inner diameter by about 2.5in in the lower part and is placed on the upper face of the drum.

B. Flanges: -

Flanges are made of MS plate having a thickness of 0.5in. There are 5 holes of diameter 1.75in each equally distributed on the diameter of the flanges.

The flanges are machined to get a circular section of diameter 8 in and 9in. There are 3 flanges having 8in diameter and 3 flanges having 9in diameter.

C. Pipes/tubes: -

Pipes or tubes used are C class pipes of external diameter 1.75in and internal diameter 1.5in. The material of the tube is MS. The tubes are cut into lengths of 16in (5nos.) 23in (5nos.) and 21in (5nos.). These pipes are to be welded to the flanges after passing them through the drums. The pipes act as the carriers for the flue gases from the flame.

D. Outside pipes:-

The tubes used for the transfer of water from the pre heater into the water drum and the transfer of steam from the water drum to the super heating drum is made of C class MS pipe having internal diameter of 0.5in and external diameter of 0.75in.

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E. Outlet pipe:-

The pipe used for the extraction of steam from the drum is made of C class GI having an internal diameter of 1in.

F. Chimney:-

The chimney is made of folded GI sheet having 1.5mm thickness which consists of a frustum of a cone and a pipe.

G. Stand:-

The stand is made using angle section of dimension 50x50x6. The angles are attached to the drum by bolting it to angle section welded to the lower water drum. The stand is separated by an angle of 120°. And the inclination of the stand to the ground is 45°.

VI. MOUNTINGS LIST

A. Pressure gauge:

A bourdon tube pressure gauge is fitted on to the middle drum of the boiler. This is to ensure that the operator always gets the value of the steam that he can release outside the boiler. It is also helpful in the calibration of the safety valve. The max pressure that the pressure gauge can read is 10.6 Kgf.

B. NRV:

Non return valve is used in the water line from the pre heater to the lower drum. It is of 0.5in diameter and is of vertical type. The main function of the NRV is to prevent the entry of the boiling water from the lower drum to the pre heater.

C. Safety valve:

The safety valve is used to let the steam out of the super heating drum if the pressures in the super heating drum increases than the set value. The safety valve is spring loaded type and is of an open type and is of vertical in nature and has a dimension of 1in.

D. Water level indicator:

Water level indicator is fitted on to the lower drum. It has two entrance points of which one allows steam to enter the glass tube and the other allows the water in the drum to enter. By looking at the water level in the water level indicator, the operator can know the level of the water present in the lower drum.

E. Valves:

All the manual valves used in the boiler are of 0.5in and are globe valves. There are 2 valves that are used:

i. The valve allowing the passage of water from the pre heater to enter the water drum

ii. The valve that allows the steam produced in the super heater to be let out

VII. WORKING

The water from the pre heater is sent to the lowermost drum via external pipes. Water in the lowermost drum gets heated up as the fire is provided directly beneath the lower drum. The heated up water turns into steam and this steam is transferred into the middle drum via external pipes. The steam gets super-heated in the middle drum. The output from the middle drum is taken via external outlet pipes.

The flow of water from the upper most drum to the lower most drum is controlled using a globe valve. This is to ensure that the cold water does not come in contact with the boiling water in the lower drum. But as soon as the water level in the gauge glass falls below a certain level the water from the top drum is again fed into the lower drum. This is done by continuously monitoring the quantity of water in the gauge glass. This is important in order to avoid thermal shocks that would be produced if cold water is suddenly rushed into the heated up flanges.

The water from the lower most drum gets boiled and gets transferred to the middle most drum where it is further heated. It is during this stage that the steam gets super-heated. The safety valve and the pressure gauge are fitted onto the middle drum. The safety valve blows off when the pressure rises above a particular value and the pressure gauge shows the corresponding value of pressure in the drum. The operator monitors the pressure gauge reading and when the intended pressure of steam is reached, opens the valve thus letting out the steam.

The top most drum also has the fire tubes passing through them and hence also adds some small amount of heat to the water. This further prevents the chances of thermal shocks due to the difference in the temperatures of the flanges and water from the top drum.

The fire tubes passing through the drum as are not in a same line provide a swirling effect to the flue gases passing through them and hence increase the heating capacity of the flue gases. As the spaces between the flanges are empty these spaces act as houses for this swirling to take place.

The chimney on top of the top most drum provides suction to the flue gases and hence aid in the successful pulling of the flue gases from the fire to the top of the top drum. This suction is provided due to the fact that the area of the chimney decreases as one goes upwards, this reduction in area also reduces the pressure at top. The flue gases flow from a position at higher pressure to a position at lower pressure and hence this provides a natural draught to the flue gases.

VIII. ANALYSIS

A. Middle drum

The analysis of the middle drum was done by applying pressure equitant to 10 bar from the inside of the drum acting in the radial direction. The boundary conditions were that the top and the bottom faces of the drum were

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constrained to give zero displacement and zero rotation in all possible directions.

Table 1. Analysis of middle drum

Property	Minima	Maxima
Displacement	0mm	6.083e-3mm
Stress	2.739 MPa	17.043 MPa
FOS	36.42	226.47

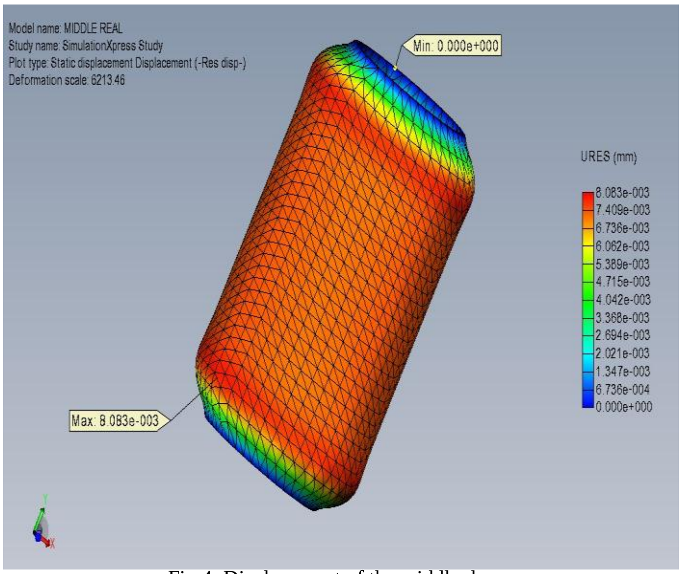

Fig 4. Displacement of the middle drum

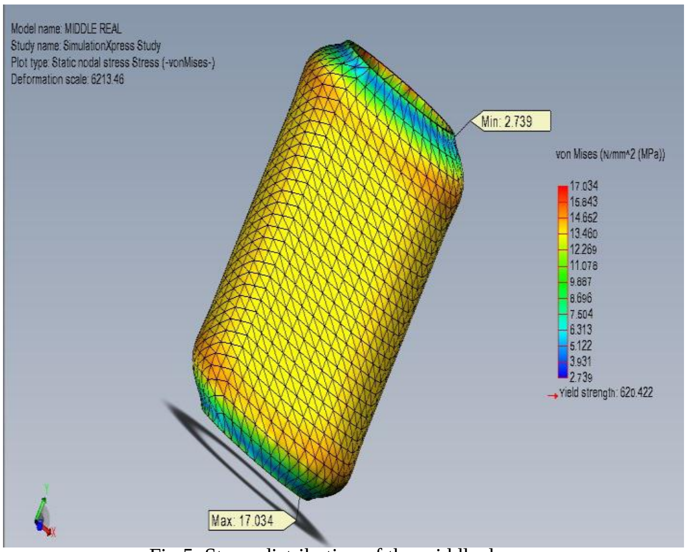

Fig 5. Stress distribution of the middle drum

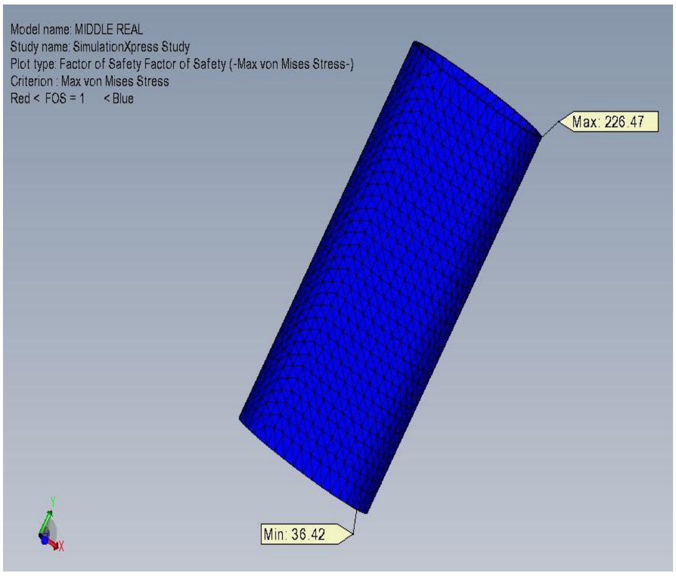

Fig 6. FOS of the middle drum

B. Middle pipe:-

The analysis of the middle pipe was done by applying pressure equitant to 10 Bar to the outside of the drum acting in the radial direction. The boundary conditions were that the top and the bottom faces of the drum were constrained to give zero displacement and zero rotation in all possible directions.

Table 2. Analysis of middle pipe

Property	Minima	Maxima
Displacement	0mm	7.648e-4mm
Stress	1.543MPa	7.926MPa
FOS	78.28	402.09

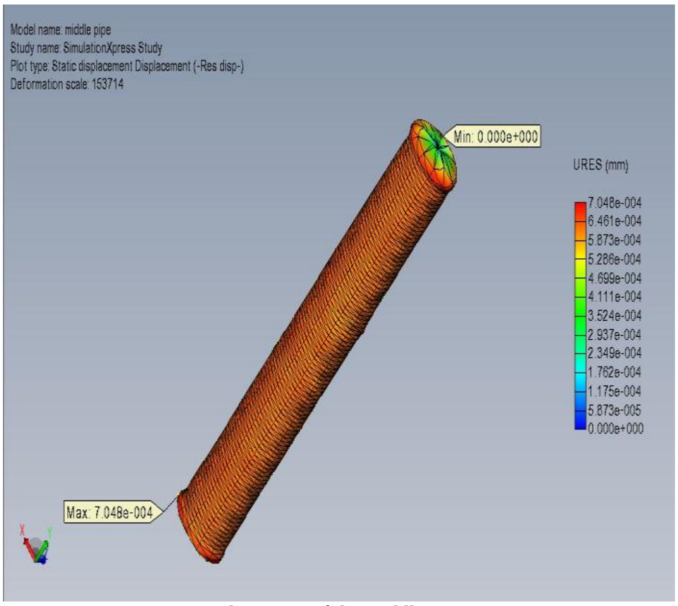

Fig 7. Displacement of the middle pipe

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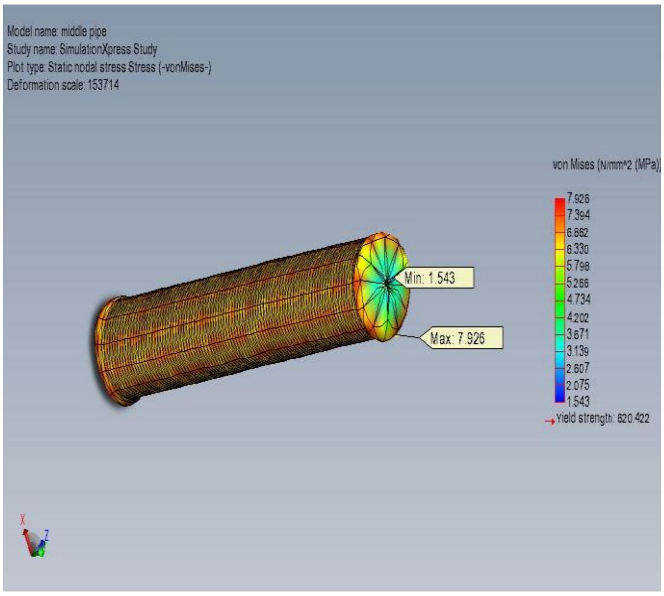

Fig 8. Stress Distribution of the middle pipe

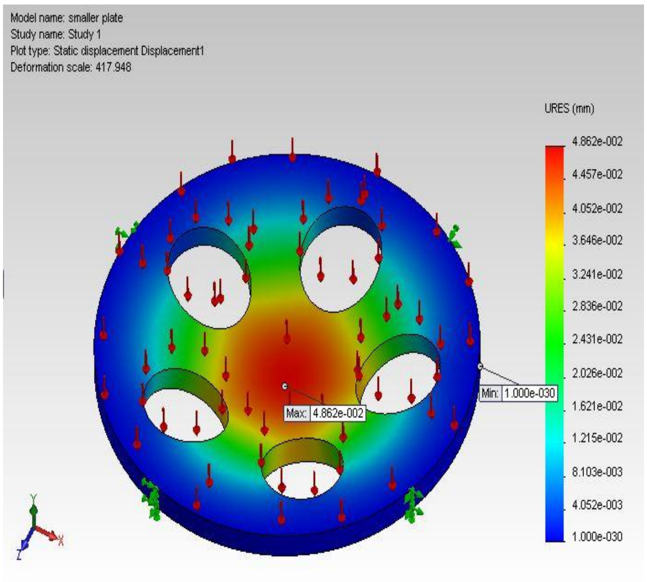

Fig 10. Displacement of the flanges

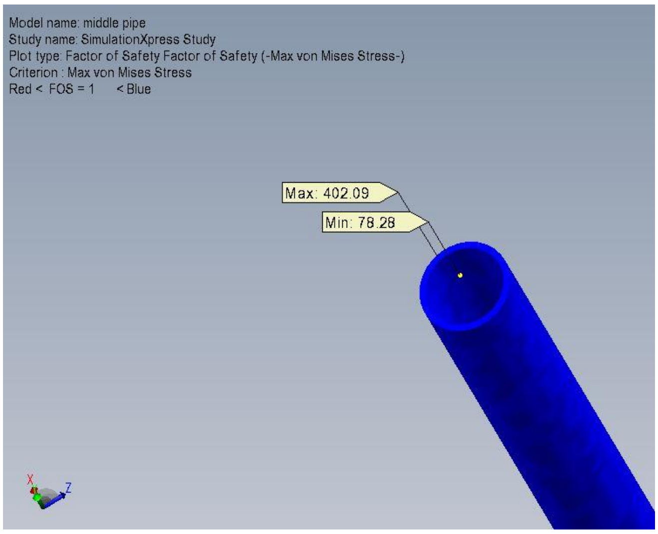

Fig 9. FOS Distribution of the middle pipe

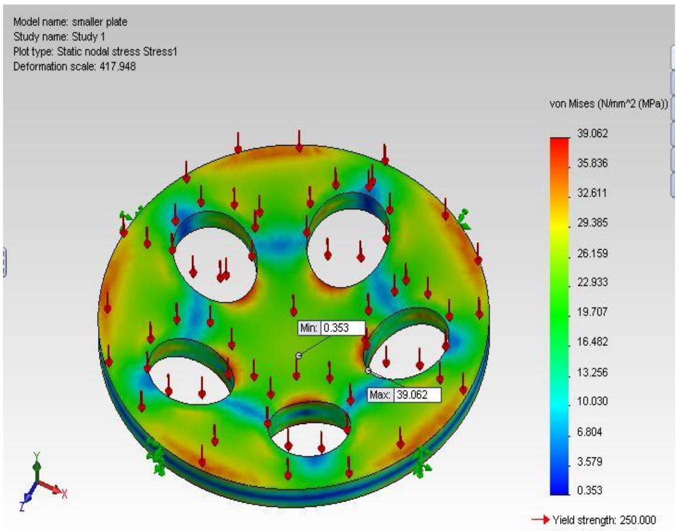

Fig 11.stress distribution of the flanges

C. Flanges:-

The analysis of the flange was done by applying pressure equitant to 10 bar to the face of the flange in the axial direction. The boundary conditions were that the circumference of the flange was constrained to give zero displacement and zero rotation in all possible directions.

Table 2. Analysis of Flange

Property	Minima	Maxima
Displacement	0mm	4.862e-2mm
Stress	3.5MPa	39.06MPa
FOS	6.40	708.72

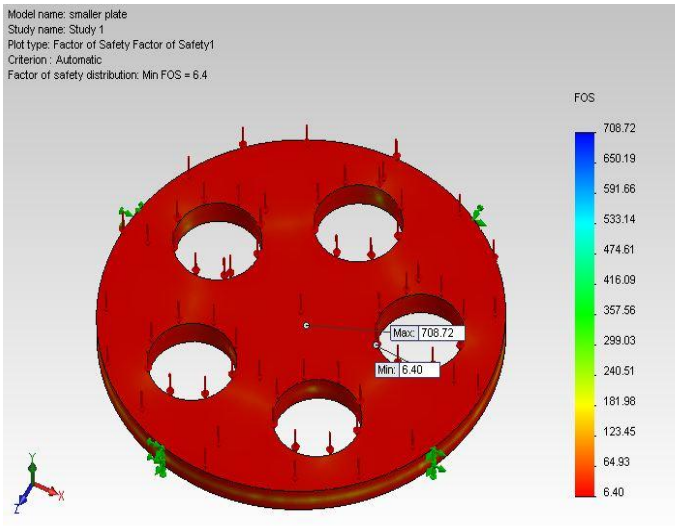

Fig 12. FOS distribution of the flanges

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REFERENCES

[1] Nygard.F,Numerical,Investigation of laminar flow characteristics in helically coiled fined tubes,2011

[2] Popov.I.A,Industrial, Applications of Heat transfer Enhancement: the modern state of the problem (a Review),2012

[3] Pawar.S.S, Experimental studies on heat transfer to Newtonian and Non-Newtonian fluids in helical coils with laminar and turbulent flow,2013

[4] AcharyaNarasimha,Analysis of heat transfer enhancement in coiled tube heat exchangers,2000

[5] Cengel.A.Yunus,Heat and Mass Transfer, Tata McGraw Hill Publication,2011

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